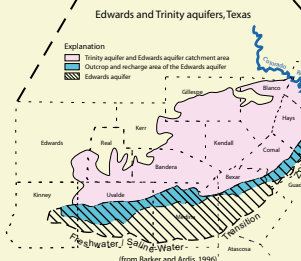


Cretaceous Volcanic Intrusives in the Edwards Aquifer, Texas, as Identified from a High-Resolution Aeromagnetic Survey

by David V. Smith, Bruce D. Smith, Charles D. Blome, Herbert A. Pierce, and Rebecca B. Lambert (USGS)

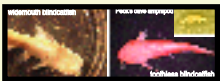
A PRODIGIOUS AQUIFER



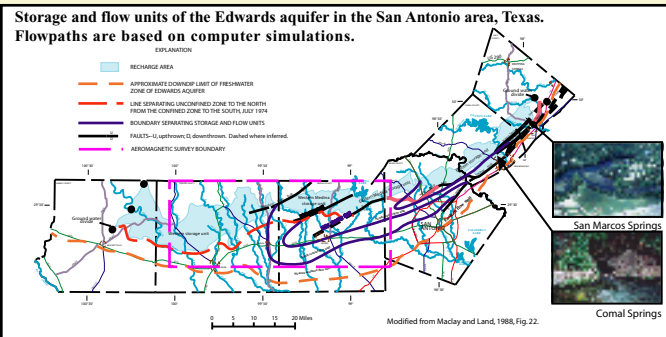
The Edwards aquifer is the major source of water for more than 1.5 million people in the San Antonio area, and provides nearly all the water used for industrial, military, irrigation, and public supplies. The Edwards aquifer was the first aquifer to be designated as a sole-source aquifer under the Safe Drinking Water Act. The Edwards feeds Comal Springs, the largest spring in the southwest with an average historic discharge of 300 cfs, and San Marcos Springs, average historic discharge of 161 cfs. Both supply water to downstream users, sustain critical habitat for federally listed endangered species, and support a vigorous tourism economy.

Increased knowledge about the complex hydrologic processes that control water availability in the Edwards aquifer is imperative for optimal resource management. Optimizing the use of the aquifer while ensuring that present and future needs are satisfied is the ultimate goal for the region.

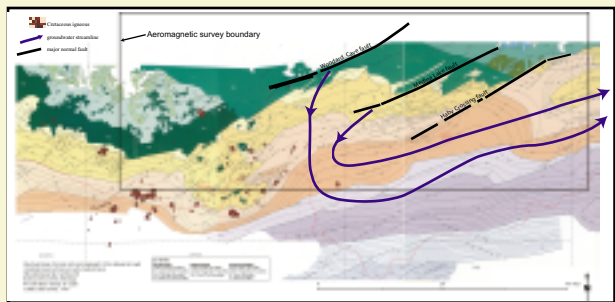
The subterranean aquifer ecosystem of the Edwards aquifer is perhaps the most diverse ground water ecosystem in the world.



(source: Edwards Aquifer Research and Data Center)



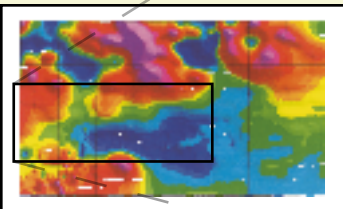
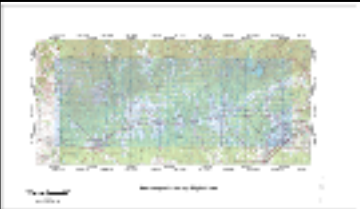
Faults, fractures and karstic dissolution channels control the regional flow regime. The Edwards hydrostratigraphic unit is completely offset along sections of major normal faults, forcing flow to the southwest. Late Cretaceous volcanism crosscut the limestones, and may have created further barriers to down-dip flow through emplacement, uplift, or alteration. So the question is: How are the unusual regional flow paths and the fresh/saline water boundary influenced by the intrusive igneous bodies?



HUNTING THE IGNEOUS INTRUSIVES



A cesium vapor magnetometer, mounted in the stinger of this twin-engine Navajo operated by Spectra Exploration Geoscience, measured variations in the earth's ambient magnetic field to better than 30 parts per million. The survey was completed in April 2001 under a cooperative agreement with the San Antonio Water System.

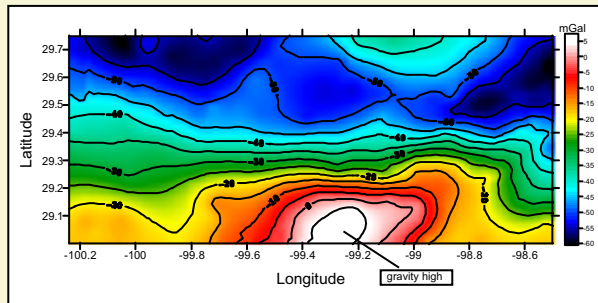


The rocks comprising the Edwards aquifer and the lower and upper confining units are essentially nonmagnetic, with magnetic susceptibilities on the order of 0.000010 emu. The igneous rocks, by contrast, have susceptibilities near 0.000400 emu.

The survey spanned the catchment area to the north, the recharge zone in the middle, and the confined zone to the south.

- Draped survey at 500 ft (155 m) above the ground
- East-west flight lines spaced 0.25 mile (400 m) apart
- North-south tie lines spaced 2.5 miles (4000 m) apart
- Over 9800 line-miles (15800 line-km) flown
- Over 2252 square miles (5833 square km) covered.

Airborne magnetic data were acquired over west-central Texas in 1980 by the National Uranium Resource Evaluation program. The airplane flew a draped survey at about 400 feet above the ground with east-west flight lines spaced 3 miles apart and north-south tie lines spaced 12 miles apart. The data shown here are residual total magnetic field. The black rectangle outlines the present study area.



Gravity data in the region reveal a high corresponding to a large magnetic high, confirming that a high density body at depth is also magnetic. The east-west trending low (blue) corresponds to the axis of a deep geosynclinal basin of the Ouachita structural belt (as described in: The Ouachita System, Bureau of Economic Geology, University of Texas). (Gravity data courtesy of R. Keller, Univ. Texas - El Paso, 2001.)

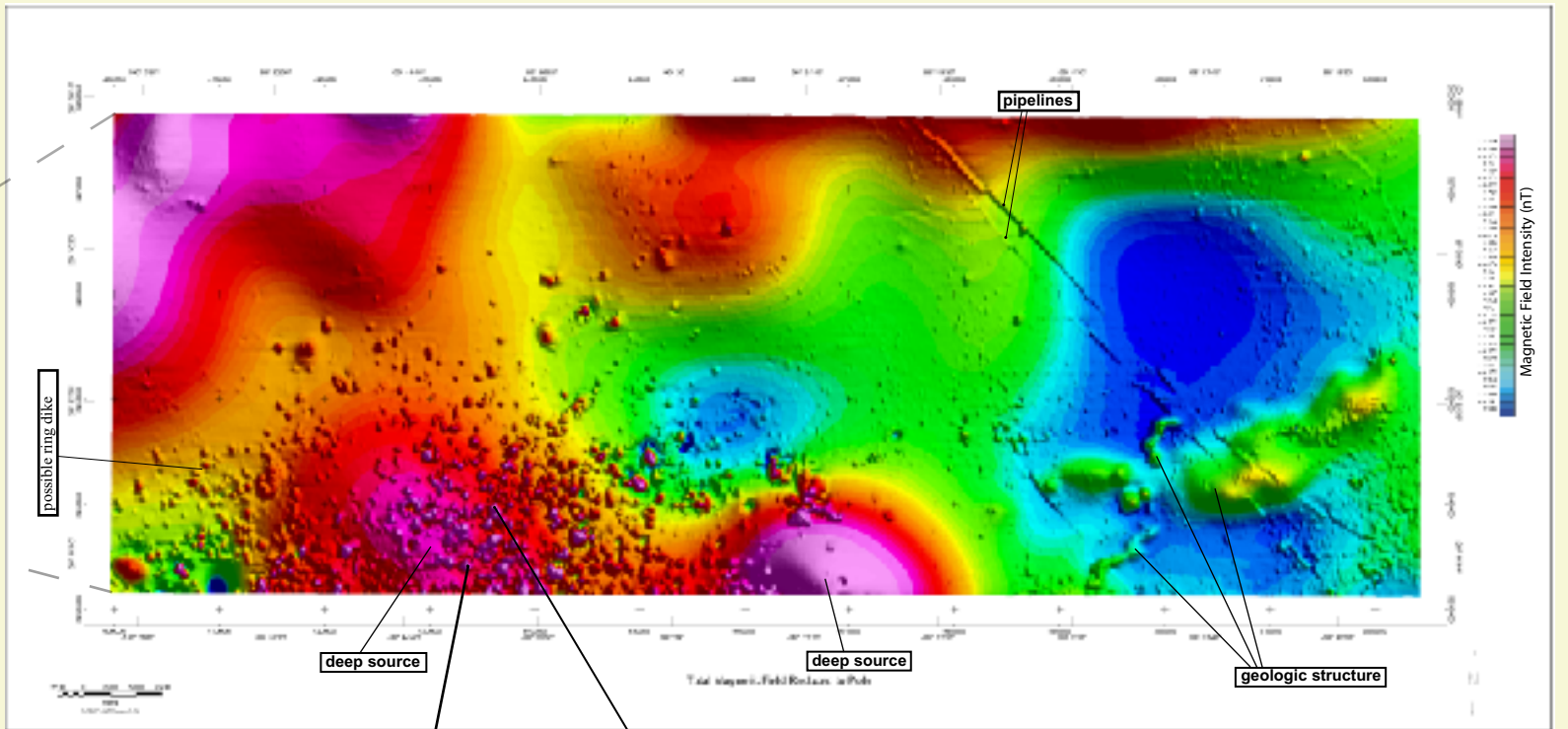


Map of mid-Cretaceous to Eocene tectonic elements of Texas

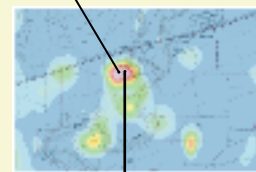
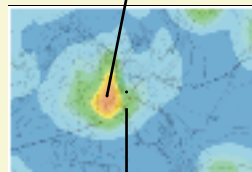


Map of Cenozoic tectonic elements of Texas

During Late Cretaceous time, the uniform subsidence history of the Gulf of Mexico was interrupted by a series of domal uplifts (including the Sabine Uplift of East Texas) and by the ascent and eruption of alkaline, ultramafic magmas. During Neogene time, all of the Western United States was uplifted, and significant extension by normal faulting created the Basin and Range structural province, which extends into Trans-Pecos Texas. Uplift of West Texas continued as far eastward as the Llano area; its eastern contact with the subsiding Gulf Coast Basin was marked by more than 500 m of displacement on normal faults of the Balcones Fault Zone. (from: The Tectonic Framework of Texas, T. Ewing, Bureau of Economic Geology, University of Texas - Austin, 1991)



The Balcones group of the alkaline [petrographic] province extends more than 200 miles from Austin, Texas, southwestward into Mexico in a belt as much as 40 miles wide. Its rocks are low-silica basalt and gabbro containing olivine, titaniferous augite, nepheline, and melilite which form plugs, dikes, sills, and possibly flows. The masses of "serpentine" locally associated with this suite are altered pyroclastic rocks, which in at least some localities are nontronite. Intrusions of the Balcones type are profuse in Uvalde and Kinney counties, Texas, where the Ouachita belt changes trend sharply, which suggests a relation between Paleozoic structures and younger intrusions. (P. Flawn in: The Ouachita System, University of Texas, 1961)



A field crew visited just two of the hundreds of mapped anomalies. A different color scale enhances the high intensity (red) of the local magnetic field against the background (blue).



This prominent outcrop along the Frio River east of Uvalde, Texas, shows water staining (light color) from periods of high flow. View towards the northwest.

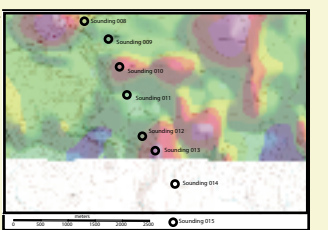
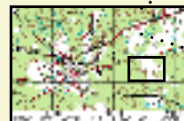


A striking example of columnar jointing can be seen in the headwall of this basalt quarry west of Knippa, Texas. The crushed rock is used for aggregate. View towards the east.

Follow-up ground geophysical surveys and further modeling of the magnetic data will give a better structural description of the intrusive igneous bodies. This information will be used to improve the three-dimensional geological map and the ground water flow model currently being developed.

Audio-Magnetotelluric (AMT) Soundings and Inverted Profile across Volcanic Features

AMT is an electrical technique that uses either natural signals or a controlled transmitter to measure earth conductivity as a function of depth, much like a conventional resistivity survey.



AMT surveys require a small field crew and are minimally intrusive, so are ideal for following up on a large reconnaissance survey. At the time of data collection, thin pyroclastic volcanic rocks were noted along the Frio River to the southeast.

The equipment (Geometrics EH-4) - portable - simple setup - fast data logging

